Catheter-Related Bloodstream Infection in Neonatal Intensive Care Unit: Prospective Surveillance Study

Infeção Nosocomial Relacionada com Cateteres Centrais em Unidade de Cuidados Intensivos Neonatais: Estudo Prospetivo

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ABSTRACT

INTRODUCTION: Intravascular catheters are substantial in neonatal intensive care units (NICU). Monitoring infection rates is increasingly regarded as an important contributor to safe and high-quality health care. Our study aimed to determine the current incidence of catheter-related bloodstream infection (CRBSI) in a level III NICU, comparing with other reports and with a previous similar study performed in our NICU in 2011.

METHODS: From January 2017 to December 2019 a prospective surveillance was undertaken in the NICU of Hospital de Braga. All newborns (NB) with a central catheter (CC) inserted in our NICU were considered. The microbiological diagnosis was performed by peripheral blood culture (BC) and the culture of the CC tip after removal.

RESULTS: There were inserted a total of 404 CC, 138 umbilical catheters (UC), and 266 peripherally inserted central catheters (PICC). The average gestational age was 30.4 weeks (SD±3.89 w), mean birth weight of 1380.03 g (SD±742.68 g), with 76.03% of very low birth weight (VLBW). The mean length of CC use was 11.51 days (SD ±11.08 d). There were 95 positive CC tip cultures, 25 (26.32%) UC, and 70 (73.68%) PICC. From 41 BC collected, there were 9 positive (21.95%), 2 from NB with UC, and 7 from NB with PICC. In both cultures, coagulase-negative *Staphylococci* were the most common organism identified. CRBSI rate is 0.5%. The incidence density of catheter contamination was 20.43 per 1000 catheter-days.

DISCUSSION: Comparing with the previous study from 2011, there is a significant improvement in the CRBSI rate, reflecting the efforts done to prevent infections. Our CRBSI rate and the infection microbiology were similar to other NICUs.

KEYWORDS: Catheter-Related Infections; Infant, Newborn; Infant, Newborn, Diseases; Intensive Care Units, Neonatal

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RESUMO

INTRODUÇÃO: *Os acessos intravasculares são indispensáveis nas unidades de cuidados intensivos neonatais (UCIN) nível III. A monitorização das taxas de infeção é considerada um importante indicador dos cuidados de saúde. O objetivo deste estudo é determinar a incidência atual de infeção associada ao uso de cateter central (CC), comparar os resultados com outras publicações e com um estudo prévio realizado na nossa unidade em 2011.*

MÉTODOS: *Estudo prospetivo realizado de janeiro de 2017 a dezembro de 2019 na UCIN do Hospital de Braga. Incluídos todos os recém-nascidos (RN) com CC colocado na nossa unidade. O diagnóstico microbiológico foi efetuado através de colheita de hemocultura e cultura da ponta do CC.*

RESULTADOS: *Foram colocados 404 CC no total, 138 cateteres umbilicais (CU) e 266 cateteres de inserção percutânea (CIP). A idade gestacional média dos RN foi 30,4 semanas (DP±3,89s), o peso ao nascer médio 1380,03 g (DP±742,68 g), com 76,03% de RN com muito baixo peso. O tempo de permanência médio dos CC foi 11,51 dias (DP±11,08 d). Obtivemos 95 culturas positivas da ponta do CC, 25 (26,32%) de CU e 70 (73,68%) de CIP. De 41 hemoculturas colhidas, 9 foram positivas (21,95%), 2 de RN com CU e 7 de RN com CIP. Os Staphylococcus coagulase-negativos foram os micro-organismos mais frequentemente identificados. A taxa de infeção associada ao uso de CC foi 0,5%. A densidade de incidência de contaminação de CC foi 20,43/1000 dias de CC.*

DISCUSSÃO: *Comparativamente ao estudo de 2011, verifica-se uma melhoria significativa na taxa de infeção associada ao uso de CC. A taxa de infeção e os agentes patogénicos identificados são semelhantes aos de outros estudos publicados.*

PALAVRAS-CHAVE: *Doenças dos Recém-Nascidos; Infeções Relacionadas a Cateter; Recém-Nascido; Unidades de Cuidados Intensivos Neonatais*

INTRODUCTION

Intravascular catheters are substantial in neonatal intensive care units (NICU). The most common types of a central catheter (CC) used in the NICU are umbilical catheters (UC) and peripherally inserted central catheters (PICC).[1] Although they provide necessary vascular access, their use puts patients at risk for local and systemic infectious complications. Monitoring infection rates is increasingly regarded as an important contributor to safe and high-quality health care.[2]

Very low birth weight (VLBW) infants (birth weight < 1500 g) are vulnerable to infections because of their immature immune systems, frequent contact with hospital personnel, and invasive procedures. CRBSI are the most common type of nosocomial infections in this population. The rates of CRBSI range from 6.4 to 8.3 episodes per 1000 patient days in the NICU, with the smallest and most immature infants being at the greatest risk. CRBSI contributes to increased morbidity and mortality, prolonged hospitalization, and the need for additional therapies. Therefore, NICU staffs have attempted to reduce infection rates by using insertion and maintenance protocols to prevent CRBSI I.[1,2]

This study aimed to determine the current incidence of CRBSI of our level III NICU, characterized the microbial profile, and then compare the results with other published reports and with a previous similar study performed in our NICU in 2011.

METHODS

A prospective study was performed in a level III NICU including all NB admitted to the unit of Hospital de Braga between January 2017 and December 2019. All CC were placed in our unit, following an internal protocol with maximal barriers precautions, skin antisepsis with 2% chlorhexidine solution until June of 2019 and since then with octenidine dihydrochloride phenoxyethanol product (Octiset®) and transparent dressing were used.

The CCs used were umbilical artery and vein catheters (UAC and UVC, respectively) and PICC. For each CC, it was collected, from the medical records, the following data: gender, gestational age, birth weight, type of CC, duration of CC use, and cultures [blood culture (BC), and CC tip culture].

CRBSI is defined as a laboratory-confirmed bloodstream infection with a positive CC tip culture and BC, including the detection of a pathogen with the same antimicrobial susceptibility test in both cultures.[3] All the CC tips were collected to a sterile contender and sent to the microbiology laboratory; BC were obtained through a peripheral vein catheterization until 48 hours after CC removal. It was performed antimicrobial susceptibility testing of

all positive CC tip cultures and BC. The clinical Pathology Department of the hospital used classic methods, internationally standardized, to identify, characterize, and to perform the antimicrobial susceptibility testing of the organisms recovered from cultures.

Taking each CC as a study unit, a descriptive and comparative study of the variables was carried out. The X^2 and Mann-Whitney test were applied. Differences that had a random probability (*p*) less than 0.05 were considered statistically significant. For the statistical study, the Statical Package for Sciences program in version 25.0 was used for the Window operating system (SPSS, Inc.).

RESULTS

During the period of study, there were 1536 newborns admitted to the NICU, and 251 of them needed CC. A total of 404 CC was inserted in our unit: 138 (34.16%) UC, 61/138 UAC and 77/138 UVC, and 266 (65.84%) PICC. Concerning the CC materials, the majority were polyurethane catheters (n=303), following by polyvinylchloride (PVC) (n=95) and silicone (n=6).

In our cohort, 52.48% of all NB were males (n=212). The most common NICU admission diagnosis was prematurity (80.9%), followed by sepsis (7.7%) and respiratory distress syndrome (3.9%). The global mean gestational age of all NB admitted to the NICU was 30.4 weeks [standard deviation (SD) ± 3.89 w], average birth weight of 1380.03 g (SD ±742.68 g), with 76.03% of VLBW. The mean length of CC use was 11.51 days (SD ±11.08 d).

The mean gestational age of newborns with UC (Table 1) was 29.60 weeks (SD ± 4.58 w), an average birth weight of 1361.00 g (SD ±977.44 g), 79.52% of VLBW. The UC was inserted during the first day of life in all newborns, except in 3 cases in which it was inserted during day-2 of life. The mean length of UC use was 3.30 days (SD ±1.89 d), with a total of 456 days of umbilical catheterization.

In the group of newborns with PICC (Table 1), the mean gestational age was 31.00 weeks (SD ± 3.41 w), an average birth weight of 1389.97 g (SD ±585.32 g), with 74.32% of VLBW. Usually, the PICC was inserted during day-2 of life (minimum 0d; maximum 68 d). The mean length of PICC use was 15.76 days (SD ±11.47 d), with a total of 4193 days of PICC catheterization.

All of the CC tips were sent to the Clinical Pathology Department for microbiological analysis, except 15 of them (n=389). There were 41 BC, collected until 48 hours after the CC removal (Table 2).

TABLE 1. Comparison of groups of NB with UC *vs* PICC.

	UC	PICC
Mean gestational age, weeks (SD)	29.60 (± 4.58)	31.00 (± 3.41)
Mean birth weight, g (SD)	1361.00 (± 977.44)	1389.97 (± 585.32)
% of VLBW	79.52%	74.32%
Mean length of CC use, days (SD)	3.30 (± 1.89)	15.76 (± 11.47)
Days of catheterization, days	456	4193

UC – umbilical catheter; PICC – peripherally inserted central catheters; SD – standard deviation.

TABLE 2. Comparison of cultures obtained from CC tip and BC.

	CC tip culture	BC
Sample (*n*)	389	41
Number of positive culture (*n*/%)	95 / 24.42%	9 / 21.95%
% of CoNS	82.88%	89.88%
% of *Staphylococcus epidermidis*	46.03%	74.34%

CC – central catheter; BC – blood culture; CoNS – coagulase-negative *staphylococci*.

TABLE 3. Pathogens identified in CC tip cultures and BC.

	UC tip culture	PICC tip culture	BC
Staphylococcus epidermidis	15	36	6
Staphylococcus haemolyticus	5	11	1
Staphylococcus homini	2	10	1
Klebsiella pneumoniae	0	2	-
Enterococcus cloacae	0	3	1
Enterobacter faecalis	0	4	-
Acinetobacter baumanii	1	0	-
Serratia marcescens	2	1	-
Bacillus pumilus	0	2	-
Candida parapsilosis	0	1	-

UC – umbilical catheter; PICC – peripherally inserted central catheters; BC – blood culture.

There were 95 positive CC tip cultures (24.42%), 25 (26.32%) from UC and 70 (73.68%) from PICC. Most of the bacteria isolated (83.16%) were CoNS, *Staphylococcus epidermidis* (53.69%), *haemolyticus* (16.84%), and *hominis* (12.63%). There were three cases with fungi, two with *Bacillus pumilus* and one with *Candida parapsilosis*. Other microorganisms identified were *Klebsiella pneumoniae*, *Enterobacter cloacae*, *Acinetobacter baumannii*, *Enterococcus faecalis* (Table 3).

From the total of 41 BC collected, there were 9 positive (21.95%), 2 from NB with UC and 7 from NB with PICC. As verified with CC tip cultures, there was also a

higher prevalence of CoNS (88.89%) and the most common bacteria was *Staphylococcus epidermidis* (66.67%) (Table 3).

In two cases it was isolated the same organism in both BC and CC tip culture. One case of CRBSI due to *Staphylococcus epidermidis* in an NB with PICC and another case of CRBSI due to *Enterobacter cloacae* isolated in both UAC and UVC. So, there is a global CRBSI rate of 0.5% (2/404).

In our NICU, for a total of 4649 days of CC, the incidence density of catheter contamination and CRBSI is 20.43 and 0.43 per 1000 catheter-days, respectively.

From the comparison statistical analysis, it was also found that there was no statistically significant difference between the CRBSI rate in UC and PICC (p=0.764). A similar comparison statistical analysis was performed in VLBW group reaching an analogous outcome, there was also no statistically significant difference between the CRBSI rate in UC and PICC in this group (p=0.386).

DISCUSSION

There are two major definitions of blood-stream infections associated with CC: CRBSI and central line-associated bloodstream infections (CLABSI). CRBSI refers to the presence of bacteremia originating from the CC.[1,4] To diagnose this, a BC and CC tip cultures with simultaneous identification of the same organism is required.[1,3] However CLABSI, is that bacteremia occurs with a central line in place or within 48 hours of a central line removal with clinical symptoms of sepsis and no other apparent source of infection, with or without positive culture through the CC. Since culturing the CC tip or BC is not a criterion, that may overestimate the true rate of CC-related infections.[1,4] This is one of the reasons why we used the CRBSI definition in this study.

The total period of CC use should not exceed 5 days for UAC and 14 days for UVC.[4] In our study we verified that these guidelines were followed by the NICU team.

The CRBSI rates range from 0 to 20/1000 catheter-days, according to several studies.[5-7] Different definitions of CRBSI used with a lack of standardized international units turn a difficult task to compare results. In this particular case, our NICU rate CRBSI is below of numbers found in the literature.[1]

In 2011, in our NICU, it was performed an internal similar prospective surveillance study including all NB admitted to the unit between January 2007 and April 2010. There were inserted a total of 124 catheters. The mean birth weight of NB was 1229.0 g (±703.5 g), with 79.8% of VLBW NB and mean gestational age of 29.2 weeks (±3.4 weeks). The results showed a rate of CRBSI of 8.9%, with CoNS as the most common organism identified. Comparing with the previous study from 2011, there is an important reduction of CRBSI rate (6.3 to 0.43 per 1000 catheter-days) and incidence density of catheter contamination (36.1 to 20.43 per 1000 catheter-days). Probably due to improvement in measures to prevent catheter-related infections, as well as to the implementation of care bundle strategy and significant efforts to improve professionals' skills (including medical and nursing staff).

Care bundles are used to prevent healthcare acquired infections and when applied correctly, they are likely to significantly reduce certain healthcare acquired infections. The most common technical elements included the use of a specific skin preparation protocol, maximal standard barrier precautions, and a daily assessment of the need for the central line.[8] Since 2014 it is used in our NICU a care bundle including a proper hand hygiene, skin antisepsis with octenidine dihydrochloride phenoxyethanol (Octiset®), transparent dressing and optimal catheter selection.

In the NICU population, the etiological organism of CRBSI is similar to that among adults, but the proportion of gram-negative organisms such as *Klebsiella pneumoniae*, *Escherichia coli*, and *Enterobacter cloacae* is relatively high. This is due to increased bacterial translocation from the gastrointestinal tract, especially in babies receiving long-term TPN which is associated with impaired bowel wall function and primary mucosal pathology, gastrointestinal surgery, or lack of enteral nutrition. While gram-positive bacteria including CoNS and *Staphylococcus aureus* are more important in developed countries, gram-negative bacteria are found more often in developing countries.[4,7] Uncommon micro-organisms such as *Enterobacter* spp., *Serratia marcescens*, or *Candida parapsilosis* are identified in some circumstances.[9] These results are similar to our study, the microbial profile of the authors' NICU is identical. The positive microbiological CC tip cultures without positive BC, were probably due to contamination during the process of CC removal, by touching the skin or any surface. One major negative point of our study is the lack of BC collected after CC removal. BC were collected only in cases of clinical and/or biochemical sepsis.

Some authors reported that low birth weight is the most important factor in the occurrence of CRBSI.[9,10] Badr *et al* concluded that birth weight, the duration of CC in place, and those who received TPN remained significant predictors for CRBSI.[11] Factors reported to increase the

incidence of CRBSI include low birth weight, age below 7 days, prematurity, number of CC days, mechanical ventilation, and infusion of TPN.[12-14]

A randomized clinical trial showed that the prophylactic use of heparinized saline containing vancomycin 25 ug/mL (antibiotic lock technique) markedly reduced the incidence of CRBSI in VLBW infants with PICC and did not promote vancomycin-resistant *enterococci* or CoNS. However, several issues still need to be resolved before the routine use of an antibiotic lock to prevent CRBSI.[15] In our NICU this is not practiced currently.

The prevention of CRBSI is essential to improve the outcomes and prognoses of NICU patients. It is most important to regularly educate and train professionals at each stage from before insertion to the removal of the CC.[16,17] To improve the quality of infection control, continuous efforts are needed to develop effective and safe infection control strategies for neonates and young infants.

In conclusion, there is an important improvement in rate of CRSBI in our NICU probably due to significant efforts realized, as a care bundle implemented since 2014. Further studies are needed to continue to monitor the CRSBI rate and to identifying issues to improve.

RESPONSABILIDADES ÉTICAS

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